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Reliance Electric

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Development of Ultra Efficient Electric Motors

**Quarterly Report for the Period
January-March 1998**

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TITLE

Development of Ultra Efficient Electric Motors

PROGRAM DESCRIPTION

There are four major tasks included in this project:

- 1) Design, build and test a 1000 horsepower synchronous motor with high temperature superconducting (HTS) coils operating in the 25 to 40 K temperature range
- 2) Design, build and test a 5000 horsepower synchronous motor with HTS coils operating in the 25 to 40 K temperature range
- 3) Develop and integrate closed-cycle cryogenic refrigeration systems with both motors
- 4) Develop the HTS wire and coil technology required for both motor demonstrations.

The goal of the 1000 hp motor demonstration is to build an HTS motor which is comparable in size and efficiency to a conventional motor of the same rating. The goal of the 5000 hp motor demonstration is to build an HTS motor which is half the active volume and has half the losses of a conventional motor of the same rating, and to demonstrate continuous operation of the 5000 horsepower motor at a beta test site. The project represents a vital step in the timely development of HTS motors for commercial applications.

PROGRESS

A rotor drawing review meeting was held which lead to a strategic procurement plan for the rotor cryostat of the 1000 hp HTS motor.

The design for the interconnect region between rotor cryostat and transfer coupling has been completed.

1000 Horsepower HTS Motor Development

Rotor Interconnection with Transfer coupling: The design for the interconnect region between the rotor cryostat and the transfer coupling has been completed. Expansion joints are used in the cryogenic lines to compensate the thermal movement differentials between the cryogenic lines and the rotor structure. Axially-oriented vacuum feed-throughs are used to bring current and instrumentation leads from the vacuum space of the rotor cryostat to the ambient environment. Compression type fittings will be used to connect the cryogenic lines during the prototype development stages. Eventually these joints will be welded. The design for the interconnect region incorporates the use of a sleeve to allow access to the interior of the interconnect region. A pair of split collars secures the sleeve at a position where it seals off the rotor vacuum space.

Rotor Drawing Review and Modification: The drawing checking and modification process continues. A rotor drawing review meeting was held with a focus on rotor part fabrication and assembly procedures, and alternative schemes for accelerating the manufacturing process. Multiple vendors will be utilized for timely delivery of rotor parts and assembly. To date, fabrication quotations have been received on most rotor parts.

Exciter Design: The control system conceptual design for the exciter has been completed. An exciter design meeting will be held in April. Kato Engineering will continue their effort in design and fabrication of the exciter.

Stator Development: Stator cooling issues are still under investigation. A few cooling schemes have been evaluated and a workable air-cooling scheme has been devised. The possibility of using water-cooling has not been completely ruled out.

5000 Horsepower HTS Motor Development

A series of optimal designs on the 5000 hp HTS motor has been completed. A parametric study was conducted to investigate the dependence of the motor performance. Optimized designs have been achieved at several rotor diameters that satisfy both volume and efficiency requirements compared to conventional motors.

Subcontractor Work Status

The subcontractor work performed by American Superconductor Corporation on cryogenic refrigeration system and HTS wire and coil development is summarized in a separate report (attached).

FUTURE PLAN

Next Quarter

- Complete rotor drawing checking for the 1000 hp HTS motor
- Start fabrication of the 1000 hp HTS motor parts

SPENDING

The actual program spending incurred till the end of January of 1998 at Reliance Electric is graphically presented in Figure 1 in comparison with the projected spending.

Figure 1. DoE SPI Phase 2 spending (actual vs. projected)

This data presents spending through January, 1998—spending data through the end of March is not available at this time.

DEVELOPMENT OF ULTRA-EFFICIENT ELECTRIC MOTORS PHASE II

Quarterly Report Summary (January through March 1998)

**Department of Energy Superconductivity Partnership Initiative DE-FC36-93CH10580
American Superconductor Corporation**

INTRODUCTION

In the quarter from January 1 through March 31, 1998 American Superconductor continued to concentrate on tasks in the following areas: cryogenic systems including the continued fabrication of the baseline refrigeration system, conductor fabrication addressing the conductor requirements for the 1000 HP full pole-sets and specification of the wire for the 5000 HP motor pole-sets, coil development tasks addressing fabrication and performance issues, and the fabrication of the subcoils for the full pole set and the support structures. This non-proprietary report is a brief summary of progress against the tasks addressed during this reporting period.

CRYOGENIC SYSTEMS

The cryogenic systems task specifically addresses the development of refrigeration system options that are technically and economically attractive for the motor application. The selected goals of the refrigeration system for the 1000 HP motor includes the capability to provide 60 watts of cooling at or below the selected winding operating temperature.

Baseline refrigerator system: ASC/AET is continuing the fabrication of a 60-watt refrigerator for the 1000 HP demonstration. The cold box has been fully characterized and is functioning as designed. The scroll compressor continues to work well. The control system for the expander is functioning as designed and the expander actuator has been modified. The system has been fully tested with a two-inch expander and appears to be operating correctly. The system was moved from Woburn to Westborough MA for continued performance testing in preparation for repackaging of the expander and the compressor.

Rotating cryocooler: The results of the cryocooler study reported in the last quarterly report were used to plan the next tasks in cooler development. A test rig is in detailed design to study rotation effects on key components.

CONDUCTOR DEVELOPMENT

1000 HP Fullset Coils: The wire production campaign for the 1000 HP motor has been successfully completed.

5000 HP Coils: A baseline preliminary 5000 HP motor field winding has been completed. This design was used to specify the wire for the 5000 HP motor. The development of the wire for this motor is in progress.

COIL DEVELOPMENT

The coil development effort is now concentrating on options for the 5000 HP motor field winding fabrication.

1000 HP SUBSET DEVELOPMENT

The subset assembly has been completed, and all subsets have been tested at 77K. They are ready for shipment when quality paperwork is completed. Rockwell has requested that we retain the subsets until we have conducted testing at 30K on each subset. This opportunity for additional testing will provide significant data on quench and thermal performance of all coils.

The facility for testing the sub and full pole sets at operating temperature ($\sim 30\text{K}$) is now functional and has been used to characterize the performance of the test subset. This test demonstrated that the performance of the subsets is consistent with expected performance (based on the wire used). The thermal characteristics of the coil and thermal interface to the coil appear to be well within the acceptable range. The characteristics of the assembly in vacuum also appear to be acceptable. As noted above, this assembly will now be used to characterize the quench characteristics of all of the coils to be delivered.

1000 HP FULL COILSET DEVELOPMENT

Production of the individual coils for the full pole sets is continuing. To date, 25 of the 35 coils have been wound. Eighteen of these coils have been tested. The covers and mandrels are in production.